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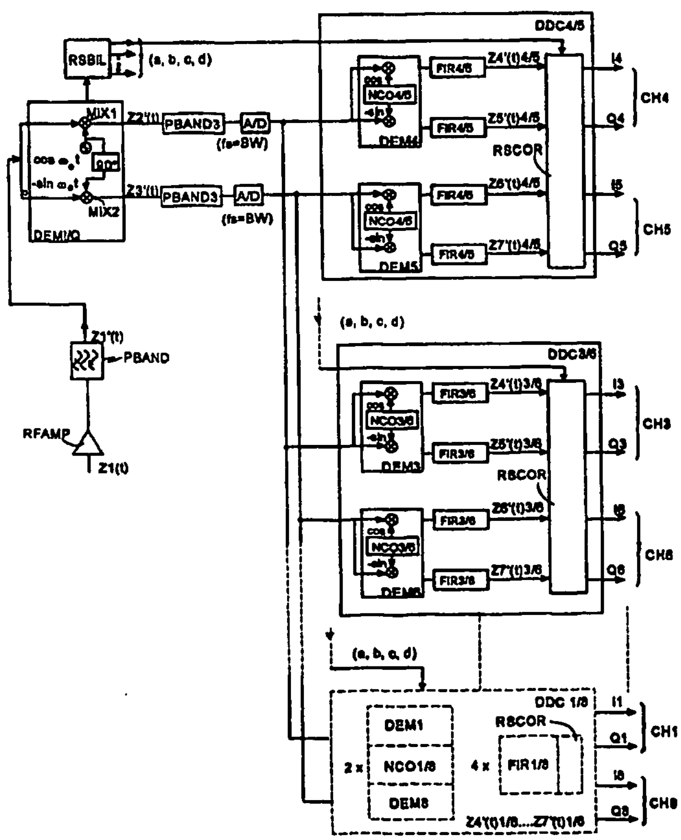
(57) Abstract

It is described a broad band digital radio receiver for multicarrier signals, such as for instance TACS or GSM, employing a quadrature demodulator (DEMI/Q) to directly shift in base band the radiofrequency signal. To this purpose, a local oscillator is used, having frequency f_0 placed at the centre of the radiofrequency BW band, in order that pairs of channels, symmetric versus f_0 are superimposed in the lower base half–band. The equivocation originated in the base band is then solved by second orthogonal demodulators (DEMx/y), of numeric type, which supply pairs of twice demodulated signals that can be grouped in four–equation systems in the four unknown values consisting of the components, in phase and in quadrature, of the two channels of each pair. Subsequent reconstruction networks (RSCOR) solve the relevant systems and give the two components of each single channel for each pair. One (RSBIL) network is foreseen in the receiver, measuring the amplitude and phase dissymmetries in the two branches of the analogue demodulator and supplying four corresponding digital coefficients (a, b, c, d) to the reconstruction network, which is thus able to conunterbalance at output the effect due to dissymmetries.



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"BROAD BAND DIGITAL RADIO RECEIVER FOR MULTICARRIER SIGNAL"

FIELD OF THE INVENTION

The present invention relates to the field of the technique concerning professional telecommunication systems, and more in particular, to a broad band digital radio receiver for multicarrier signals.

The use of the radiofrequency spectrum in telecommunication is governed by international standards assigning specific frequency bands to given services, either public or private. Inside these bands services are generally organized in order to exploit the band occupation at best, for instance, subdividing the same into a plurality of contiguous channels. Number of examples are available on this matter. A first example is represented by telephone radio links, where thousands of telephone channels are multiplexed among them, either in frequency or in time, in order to result contiguous within a microwave band. A second example is the Paneuropean telephone system, hereinafter referred to through the acronym GSM (Groupe Special Mobile), based on the time division use of even 174 carriers, 200 KHz spaced among them, modulated according to a GMSK scheme (Gaussian Minimum Shift Keying), and individually transmitted within a 35 MHz band, positioned around 900 MHz (EGSM). Reference to the GSM system is purposely made since, being the same an essentially digital system, it results a preferred field of application according to the subject invention. The digital receiver definition means that it is designed to receive signals for which the parameter, or parameters, characterizing the modulated carriers, assume a discrete number of values; in the GSM, as in the most modern telecommunication systems, the carriers are modulated in an orthogonal way, starting from a modulating signal consisting of bursts of information or synchronization bits.

A problem arising in the modern transceivers is in fact that of the conversion of the reception analogue signal into a digital format, from which the original burst has to be obtained through appropriate processing with the DSP techniques (Digital Signal Processing). The classical implementation scheme of radio receivers operating in the field of the present invention foresees at least an intermediate frequency conversion stage, followed by a demodulator and an

analogue-to-digital converter (A/D) of the demodulated signal. The reasons inducing to the intermediate frequency conversion of the signal received are multiple, among which the main one is undoubtedly that of an improved and more easy selectivity of the receiver. Of course, the presupposition for such a conversion is that to filter the signal falling in a so-called "image" band at radio frequency, since it is specular to the useful one versus the frequency f_{ol} of the local oscillator governing the intermediate frequency converter. Such a filtering is generally very complex, due to the close distance usually present among adjacent radio channels. A second problem arising, is the conversion speed of the A/D converter, since it depends on the bandwidth of the signal to be processed. The above mentioned speed corresponds to the sampling frequency f_s of a sampler of the analogue signal preceding the A/D converter. The frequency f_s must be equal to the double at least of the maximum frequency included in the BW band of the signal to be converted, as defined by the Nyquist proposition, which represents a non negligible burden in the case of broad band signals, just like multicarrier ones.

BACKGROUND ART

In order to double the band to be processed by the A/D converter, a functional diagram is shown in fig. 1 of a multicarrier receiver, simplified for description sake, to the case of only two carriers representing two adjacent channels in a comprising BW band. The receiver of fig. 1 enables to halve the sampling frequency f_s and can be obtained through the sole application of the conventional knowledge of the skilled in the art.

Making reference to fig. 1, it can be noticed a radiofrequency stage including a low-noise amplifier RFAMP for a RF input signal consisting of two carriers having f_{c1} and f_{c2} frequency, respectively, orthogonally modulated by the information conveyed by the relevant channels CH1 and CH2 associated to the same. The signal coming out from RFAMP is equally shared over two branches leading to the input of two relevant band pass filters PBAND1 and PBAND2 having width BW/2, sharing the whole RF band. The signals coming out from said filters reach two first inputs of relevant mixers MIX1 and MIX2, the second inputs of which are reached by two sinusoidal signals of local oscillator, respectively, having $f_{ol1} = f_{c1} - BW/4$ and $f_{ol2} = f_{c2} - BW/4$ frequencies. Thanks to the particular values of f_{ol1} and f_{ol2}, the two channels CH1 and CH2 are

included in the 0 to BW/2 band. Said signals are filtered by two low-pass filters, not shown in the figure, eliminating the $2f_{ol1}$ and $2f_{ol2}$ components reaching two A/D blocks operating at f_s = BW frequency. The digital signals coming out from the A/D blocks reach two DDC blocks representing some numeric demodulators in quadrature. For the detail of these blocks, reference shall be made to the description of the following figures. The components in phase I1 and in quadrature Q1 of the demodulated signal concerning channel CH1 are present at the two outputs of block DDC1 likewise the components in phase I2 and in quadrature Q2 of the demodulated signal concerning channel CH2 are present at the two outputs of block DDC2. The above mentioned components are sent to a detector block, not shown in the figure, giving back the starting information. The diagram of fig. 1 can be extended to a receiver for more than two channels, simply adding as much DDC blocks as are the new channels.

As it can be noticed from the previous description, in the receiver of fig. 1 the A/D converters operate at halved speed compared to those used in the receivers mentioned above. However, this advantage versus the background art is soon made vain by the cost of the two high selectivity, radiofrequency filters PBAND1 and PBAND2 and by the need to equip two local oscillators.

OBJECTS OF THE INVENTION

Object of the present invention is to overcome the drawbacks of the background art and of the receiver of fig. 1, and to indicate a process for the implementation of a broad band radio receiver for multicarrier signal with orthogonal modulation.

SUMMARY OF THE INVENTION

The above object is solved by the present invention regarding a process for the implementation of a broad band radio receiver for a signal consisting of a plurality of equispaced carriers, orthogonally modulated, including a radio frequency preliminary filtering with characteristic band pass for the suppression of signals not included in the band of said multicarrier signal, **characterized in that** it includes in sequence the following steps:

- direct demodulation of the signal filtered by multiplication of the same by the first two local carriers in phase quadrature, having equal frequency, corresponding to a central value of the radiofrequency multicarrier signal, superimposing by this, within a lower half of the base band, pairs of channels

symmetrically arranged versus the frequency of said first local carriers;

- first filtering in base band, broad band, of components in phase and in quadrature of the demodulated multicarrier signal, for the suppression of additional components outside the interest band;
- sampling of said filtered components, at a sampling frequency equal to the bandwidth of said multicarrier signal, and subsequent analogue/digital conversion;
- second demodulation of said digital filtered components, in phase and in quadrature, through multiplication of the components themselves by pairs of relevant second numeric local carriers in phase quadrature among them, having frequency equal to the centre band value of said pairs of superimposed channels, obtaining coinciding with said second isofrequential numeric carriers, quartet of double demodulated signals that can be analytically expressed through a linear system of four equations in four unknown values, corresponding to components in phase and in quadrature of said pairs of superimposed channels;
- solution of said linear systems obtaining the above mentioned components for each single channel of said pairs of channels, thus eliminating the equivocation in base band, as described in claim 1.

An additional object of the invention is a radio receiver implemented according to the above mentioned process. The receiver employs A/D converters operating at halved speed, like what previously described referring to the background art mentioned first. However, compared to the receiver of fig. 1 it employs only one radiofrequency local oscillator and one sole radiofrequency band pass filter having not too high selectivity, since the problem to filter the image band does not exist, compared to the two high selectivity filters and the two local oscillators required to implement the above mentioned solution of the known type. The economy is lightly penalized by the addition of N/2 numeric networks for the reconstruction of the components in phase and in quadrature of the single demodulated channels of each pair of channels that resulted superimposed in base band. As it can be noticed, in the receiver according to present invention, the most expensive analogue portion is reduced to the minimum necessary extent, in favour of the digital portion, simpler, reliable and less expensive.

The receiver object of the present invention is able to correctly operate and to show the advantages listed above, provided that the electrical behaviour of the mixers inserted in the two branches in quadrature of the analogue demodulator result perfectly symmetric. In the contrary instance, undesired components would be originated in the demodulated signal, which would prevent the network that eliminates the equivocation in base band to obtain the original values of the components in phase and in quadrature of the demodulated carriers. Incidentally, the receiver includes second demodulators with numeric mixers not introducing any unbalancing. The mentioned inconvenience can be overcome selecting for the analogue demodulator a couple of mixers, simultaneously obtained in a same manufacturing procedure, with high coupling degree of the physical parameters, assured by the manufacturer.

Would this not be enough, it is however possible to modify the receiver according to a modified process particularly useful in case of multicarrier signals for channels subject to a wide level dynamic, such as for instance the signals used in the mobile communication systems. The variant differs from the main process due to the fact that said broad band filtering of the demodulated signal is a band pass filtering suppressing from the spectrum of the signal in base band the components in a condition of null frequency and that introduces the following additional steps completely independent from the main sequence:

- measurement of the amplitude and phase dissymmetry degree on the two branches of an analogue demodulator performing said direct demodulation from radiofrequency in base band, obtaining correction factors;
- introduction of said correction factors in said linear systems of equations, obtaining still linear modified systems having the same number of equations;
- solution of said modified systems, obtaining for each single channel of said pairs the above mentioned components in phase and in quadrature, without unbalancing otherwise due to said dissymmetries on the two branches of said analogue demodulator, as described in claim 3.

Consequently, another object of the invention is an embodiment of a radio receiver according to the modified process, as described in claim 10.

BRIEF DESCRIPTION OF DRAWINGS

Additional objects and advantages of the present invention may be

understood making reference to the detailed description of an embodiment of the same, taken in conjunction with the attached drawings, in which:

- Figure 2 shows a general block diagram of the receiver according to present invention, for the case simplified to two carriers only;
- Figure 3 shows an additional embodiment of the receiver of fig. 2;
- Figures 4 and 5 represent the spectrum of the waveforms relevant to the operation of the receivers shown in figures 2 and 3;
- Figures 6 and 7 show the spectrum of the waveforms relevant to the operation of the receiver according to the embodiment shown in fig. 3;
- Figure 8 shows a DEMI/Q block shown in fig. 3 and the circuit included in a RSBIL block of the same figure;
- Figure 9 shows the circuit included in a RSCOR block of fig. 3;
- Figure 10 shows a block diagram of the radio receiver according to the additional embodiment of the present invention, for the more general case of N carriers; and
- Figures 11 and 12 show the spectrum of the waveforms relevant to the operation of the receiver according to the embodiment of fig. 10.

DETAILED DESCRIPTION

The embodiment that shall be now described in detail concerns a simplified radio receiver for the case of signals with two sole modulated carrier. However, the conclusions obtained can be directly extended to the more general case of receiver for N > 2 carriers, which better qualify the invention. This last receiver shall be shown in any case and its description will result facilitated by what said about the simplified receiver.

Making reference to fig. 2 we notice a receiver for an entering radio signal radio z1(t) consisting of two carriers, having f_{c1} and f_{c2} frequency, respectively, orthogonally modulated by the information conveyed by relevant channels CH1 and CH2 associated to the same. The signal z1(t) reaches the input of a low-noise radiofrequency amplifier RFAMP, and sent to a band pass filter PBAND, with BW bandwidth higher than or equal to the total band of the two adjacent channels CH1 and CH2, and a centre frequency $f_c = (f_{c1} + f_{c2})/2$. Downstream the PBAND filter a quadrature demodulator DEMI/Q is placed, including two mixers MIX1 and MIX2 the first inputs of which are reached by the signal z1'(t)

coming out from the filter PBAND, equally shared, and the second inputs of which are reached by relevant sinusoidal signals having frequency $f_0 = f_c$. More particularly, the second input of MIX1 is reached by a signal $\cos\omega_0 t$ generated by a local oscillator, while the second input of MIX2 is reached by a signal $-\sin\omega_0 t$, obtained from the previous signal through a 90° phase shifting circuit. The outputs of MIX1 and MIX2, a phase signal z2(t) and a quadrature z3(t) one respectively, are connected to the input of two relevant identical low-pass filters PBAS and therefore to the input of two A/D blocks including a sampler operating at f_s = BW frequency having downstream an analogue/digital converter. The outputs of the two A/D blocks are connected to two relevant inputs of a block DDC1/2 including two identical demodulators in quadrature DEM1 and DEM2, differing from DEMI/Q for being of the digital type and for the different frequency of a numeric oscillator NCO driving the comprised numeric mixers. A first input of DDC1/2 for the signal in phase z2(t), digitalized, is connected to the inputs of the demodulator DEM1, while the second input of DDC1/2 for the signal in quadrature z3(t), digitalized, is connected to the inputs of the demodulator DEM2. At the outputs in phase and in quadrature of DEM1 two signals z4(t) and z5(t) are respectively present, while at the outputs in phase and in quadrature of DEM2 two signals z6(t) and z7(t) are respectively present. The block DDC1/2 also includes four identical low-pass filters of the FIR type comprised in the four branches starting from the two pairs of outputs of the demodulators DEM1 and DEM2. The outputs of the four filters FIR are connected to a same number of inputs of a block RSOM, at the four outputs of which the components in phase and in quadrature are present, indicated with I1 and Q1 respectively, of the demodulated signal belonging to channel CH1, and the components in phase and in quadrature, indicated with I2 and Q2, respectively, of the demodulated signal belonging to the channel CH2.

Fig. 4 shows a spectral representation Z1'(f) of the z1'(t) signal consisting of the sum of two modulated signals s1(t) and s2(t) concerning the two radiofrequency channels CH1 and CH2 entering the receiver. The spectrum Z1'(f) globally occupies a band of BW width and comprises two spectrum S1(f) and S2(f), of the signals s1(t) and s2(t), centered around two relevant carriers f_{c1} and f_{c2} symmetrically arranged compared to the central frequency f_0.

Fig. 5 shows a spectral representation Z2(f) of the demodulated signal

z2(t), or indifferently a spectral representation Z3(f) of the demodulated signal z3(t), where the two spectrum S1(f) and S2(f) of fig. 4 can be noticed, shifted in base band BW/2, centered around a common frequency Δf. The representation is purposely altered for demonstration purposes, actually the spectrum in base band is the sum of the two, as it can be shortly noticed.

In the operation, making reference to figures 2, 4 and 5, and to what already known on the analytical representation of phase modulated signals, it is possible to express the signals s1(t), s2(t) and z1'(t) as follows:

$s1(t) = I1\cos\omega_1 t - Q1\sin\omega_1 t$; where: $\omega_1 = \omega_0 - \Delta\omega$, being $\Delta\omega = 2\pi\ \Delta f$

$s2(t) = I2\cos\omega_2 t - Q2\sin\omega_2 t$; where: $\omega_2 = \omega_0 + \Delta\omega$.

The signal at the input of the demodulator DEMI/Q is $z1'(t) = s1(t) + s2(t)$. Assuming that the two branches of the demodulator DEMI/Q are perfectly balanced, at the output of the component in phase we have $z2(t) = z1'(t)\cos\omega_0 t$ and at the output of the component in quadrature we have $z3(t) = z1'(t)(-\sin\omega_0 t)$ which, neglecting the $2\omega_0$ frequency terms filtered by the PBAS filter, become:

$z2(t) = ½[(I1 + I2)\cos\Delta\omega t + (Q1 - Q2)\sin\Delta\omega t]$

$z3(t) = ½[(Q1 + Q2)\cos\Delta\omega t + (I2 - I1)\sin\Delta\omega t]$

These expressions justify the spectral representation of fig. 5. The signals z2(t) e z3(t) are filtered by a low-pass filter (not visible in the figure) that eliminates the component at 2BW frequency , sampled at a sampling frequency fs = BW, , converted to digital, and respectively sent to the demodulators DEM1 and DEM2. The numeric oscillator NCO, driving the pairs of numeric mixers of both the demodulators, has a frequency Δf. The four identical low pass filters FIR eliminate possible components due to adjacent channels from the demodulated signals. The signals z4(t), z5(t), z6(t) and z7(t) at the outputs of filters FIR have the following expressions:

$z4(t) = z2\cos\Delta\omega t = ¼(I1 + I2)$

$z5(t) = z2(-\sin\Delta\omega t) = ¼(Q2 - Q1)$

$z6(t) = z3\cos\Delta\omega t = ¼(Q1 + Q2)$

$z7(t) = z3(-\sin\Delta\omega t) = ¼(I1 - I2)$

forming a linear system of four equations in the four unknown values I1, Q1, I2, Q2. The sum network RSOM solves this systems and gives the numeric values of the components I1, Q1 and I2, Q2 of the demodulated carriers relevant to

channels CH1 and CH2 through the following expressions:

$I1 = 2(z4 + z7)$

$Q1 = 2(z6 - z5)$

$I2 = 2(z4 - z7)$

$Q2 = 2(z6 + z5)$

Should one of the two channel not be present, the above mentioned solution would still be valid for the remaining channel, since the four equations of the system would no more result independent, being valid the two following relations: $z4(t) = z7(t)$ e $z6(t) = -z5(t)$, in this case two, out of the four equations could be eliminated.

The illustration supplied for the receiver of the embodiment of fig. 2 justifies the advantages ascribed to a receiver according to the present invention. In particular, the radiofrequency band pass filter PBAND can have a greatly lower selective response in frequency than that of a similar one usually employed for the suppression of the image band. In fact, in the receiver of fig. 2 the image band consists of channels belonging to the upper half band versus the frequency of local oscillator, channels that are also shifted by the demodulator directly in the lower half band of the base band, and from there discriminated through a second demodulation in quadrature and a numeric processing on the demodulated signals. Therefore, possible undesired components of the radiofrequency signal, that are transferred in base band through a broad radiofrequency filtering, do not disturb the receiver that much, because they are beyond the upper half base band.

Making reference to fig. 3 it is now examined the circuit-related embodiment that enables the receiver of fig. 2 to recover a possible dissymmetry between the two branches of the demodulator DEMI/Q, to the purpose of a correct demodulation. As it can be noticed, the receivers of figures 2 and 3 differ only due to the fact that in the receiver of fig. 3:

a) an additional RSBIL block is present;

b) the two low-pass filters PBAS of fig. 2 are now two band pass filters PBAND3 that, as it shall be seen, differ from PBAS due to the fact to suppress from the spectrum of the signal in base band the components around the null frequency; and

c) that the block RSOM of fig. 2 is called RSCOR, meaning by this a different

operation mode.

In the operation, the block RSBIL receives the information from DEMI/Q and communicates in its turn information to RSCOR. This representation is in line with the object of the embodiment, which intends to introduce in the receiver a circuit measuring the above mentioned dissymmetries, in particular the RSBIL block, and a network capable to counterbalance the same, through the use of the reconstruction network RSCOR. This last is obtained appropriately modifying the sum network RSOM of fig. 2. The following considerations will be helpful to clarify the operation of the RSBIL and RSCOR blocks, whose detailed representation is given in figures 8 and 9, shown below. From the physical point of view, the cause for dissymmetries can be ascribed to some difference in the two analogue mixers MIX1 and MIX2 of the demodulator DEMI/Q; whose repercussions on the analytical plan are those of the origination of two relevant components in quadrature in the expressions of the voltage z2(t) and z3(t) coming out from DEMI/Q of fig. 2. These new components unbalance the inputs of the reconstruction network RSOM and invalidate the operations made by the same. In the following analytical description, two parameters k1 and k2 are introduced to indicate the amplitude unbalancing of the signals between the two branches of the demodulator, and other two ones ε_1, ε_2 to indicate the phase unbalancing. It is also convenient to assume the following positions:

$a = ½k1\cos\varepsilon_1$

$b = -½k1\sin\varepsilon_1$

$c = ½k2\sin\varepsilon_2$

$d = ½k2\cos\varepsilon_2$

It can be easily demonstrated that in presence of dissymmetries the expressions of z2(t) and z3(t) transform into the following expressions, indicated with z2'(t) and z3'(t) in fig. 3:

$$z2'(t) = ½k1\{\cos\varepsilon_1[(I1 + I2)\cos\Delta\omega t + (Q1 - Q2)\sin\Delta\omega t] + - \sin\varepsilon_1[(Q1 + Q2)\cos\Delta\omega t + (I2 - I1)\sin\Delta\omega t]\} =$$

$$= 2az2(t) + 2bz3(t)$$

$$z3'(t) = ½k2\{\cos\varepsilon_2[(Q1 + Q2)\cos\Delta\omega t + (I2 - I1)\sin\Delta\omega t] + + \sin\varepsilon_2[(I1 + I2)\cos\Delta\omega t + (Q1 - Q2)\sin\Delta\omega t]\} =$$

$$= 2dz3(t) + 2cz2(t)$$

From which, as re-test, z2(t) and z3(t) can be newly obtained as in the particular case of absence of unbalancing, that is for $k1 = k2 = 1$ and $\varepsilon_1 = \varepsilon_2 = 0$. The signals z2'(t) and z3'(t) reach the inputs of DEM1 and DEM2 respectively, at the outputs of which we have two relevant pairs of signals z4'(t), z5'(t) and z6'(t), z7'(t).

The expressions of these new signals are the following:

$z4'(t) = z2'(t)\cos\Delta\omega t = [2az2(t) + 2bz3(t)]\cos\Delta\omega t = a/2(I1 + I2) + b/2(Q1 + Q2)$

$z5'(t) = z2'(t)(-\sin\Delta\omega t) = [2az2(t) + 2bz3(t)](-\sin\Delta\omega t) = a/2(Q2 - Q1) + b/2(I1 - I2)$

$z6'(t) = z3'(t)\cos\Delta\omega t = [2dz3(t) + 2cz2(t)]\cos\Delta\omega t = d/2(Q1 + Q2) + c/2(I1 + I2)$

$z7'(t) = z3'(t)(-\sin\Delta\omega t) = [2dz3(t) + 2cz2(t)](-\sin\Delta\omega t) = d/2(I1 - I2) + c/2(Q2 - Q1)$

forming a linear system of four equations in the four unknown values I1, Q1, I2, Q2. The reconstruction network RSCOR receives at input the values z4'(t), z5'(t), z6'(t), z7'(t) and coefficients a, b, c, d, which appear as correction terms, solves this problem and supplies the numeric values of the components I1, Q1 and Q2, Q2 of the demodulated carriers relevant to channels CH1 and CH2 through the following expressions:

$$I1 = \frac{d \cdot z4' - c \cdot z5' - b \cdot z6' + a \cdot z7'}{ad - bc}$$

$$Q1 = \frac{-c \cdot z4' - d \cdot z5' + a \cdot z6' + b \cdot z7'}{ad - bc}$$

$$I2 = \frac{d \cdot z4 + c \cdot z5 - b \cdot z6 - a \cdot z7}{ad - bc}$$

$$Q2 = \frac{-c \cdot z4 + d \cdot z5 + a \cdot z6 - b \cdot z7}{ad - bc}$$

As it can be notices, the expressions solving the systems are more complex than the similar expressions relevant to the receiver of fig. 2; this is in line with the scope of the embodiment of fig. 3 that has the purpose to eliminate the imperfection of the analogue demodulator through a correction in the digital domain. It must be pointed out that the solutions exist only if the determinant of the system *ad - bc* placed at denominator does not become null, as it occurs for

$\varepsilon_1 = \varepsilon_2 = 45°$, being this situation very unlikely in practice due to the high dissymmetry value. Should particular relations exist between the components in phase (I) and in quadrature (Q), the expressions solving the system can be simplified.

Such an approach is absolutely necessary in presence of multicarrier signals for channels subject to a wide level dynamic, such as for instance the signals used in mobile communication systems. In lack of correction, in fact, a low level channel could be blind by a fraction k of the image signal that superimposes to the useful signal, attenuated by 20 or 30 dB. This phenomenon is due to imperfections in real quadrature analogue demodulators.

Referring to fig. 8 it can be noticed the RSBIL network for the calculation of coefficients a, b, c, d. Said network, represented with a sole block in fig. 3, is here more realistically shown in a circuit-related detail that articulates around the demodulator DEMI/Q. The RSBIL network includes a two-input adder SOM, a three-position selector SEL, two identical low-pass filters LPF, two identical AGC blocks for the automatic gain control, and finally two identical A/D blocks for the analogue/digital conversion. The radiofrequency signal z1'(t) reaches a first input of the adder SOM, whose second input is connected to the mobile cursor of SEL. The output of the adder SOM is connected to the inputs of the demodulator. The central position of the selector SEL is free from connections, while the two selection positions are connected to relevant inputs driving the two mixers MIX1 and MIX2 inside the block DEMI/Q. Therefore in these positions, the local oscillator signals $\cos\omega_0 t$ and $-\sin\omega_0 t$, respectively shall be selected. The phase output of DEMI/Q is subdivided into two branches, a first branch is connected to the input of a cascade of blocks consisting of a first low-pass filter LPF, a first AGC and a first A/D converter, whose output gives the coefficients a, b. The second branch of the output in phase of DEMI/Q corresponds to the branch in phase coming out from DEMI/Q, shown in fig. 3. The output in quadrature of DEMI/Q is it too subdivided into two branches, a first branch is connected to the input of a cascade of blocks formed by the second low-pass filter LPF, the second AGC and the second A/D converter, whose output gives the coefficients c, d. The second branch of the output in quadrature of DEMI/Q corresponds to the branch in quadrature coming out from DEMI/Q, shown in fig. 3. The operation of the network RSBIL is now illustrated with the aid of

figures 6 and 7.

Fig. 6 shows the spectrum S1(f) and S2(f) of fig. 4 with the local oscillator tone at the centre, in the two forms $\cos\omega_0 t$ or $-\sin\omega_0 t$, respectively.

Fig. 7 shows the representation in base band of fig. 5, after demodulation, including also a null frequency line, obtained from the output of MIX1 and MIX2, due to the beating of the signal of local oscillator, with itself or with its form in quadrature.

Concerning the operation of the RSBIL network, when the cursor of SEL is turned on the position carrying the signal $\cos\omega_0 t$ to the second input of the adder SOM, the correction values a, c appear at output from the A/D converters; on the contrary, when $-\sin\omega_0 t$ is selected, the correction values b, d appear. It can be noticed that the selector SEL enables to use the signal of local oscillator as sample signal for the measurement of the dissymmetry existing on the two branches of the analogue demodulator DEMI/Q, and also that this measure, and consequently the updating of the correction factors a, b, c, d, are completely independent from the normal operation of the receiver. In fact, the adder SOM enables the input signal z1'(t) to reach the demodulator DEMI/Q even in presence of the test tone that, as shown in fig. 7, does not disturb the demodulated channels, since it is not allocated in the band of the channels. Furthermore, once the updating is completed the cursor can be switched to the central high impedance position, the new correction values will remain stored in memory registers of the RSCOR network, not shown in fig. 9. Of particular importance for the correct operation of the RSCOR network is the fact that the feedback of the signals of local oscillator on the input of the demodulator DEMI/Q does not introduce itself a significant phase and amplitude distortion in respect with that one intends to correct. A means to reduce the effects of this possibility, could be that to evaluate the unbalancing in absence of the input signal z1(t), not to overload the two mixers. Essential importance has also the accuracy in the evaluation of the correction parameters a, b, c, d, because the correspondence degree of the components I1, Q1, I2, Q2 to the values transmitted depends on the same. To this purpose, two A/D converters must be employed, having enhanced level dynamic; the AGC placed upstream the A/D help to better exploit said dynamic, since they compress the level dynamic of the signal almost constant coming out from the low-pass filters LPF within a value

interval more suitable to the good operation of the A/D. Fig. 7 shows the total spectrum of the demodulated signal z2'(t), or z3'(t), in presence of the test tone. It can also be noticed the masks of filters LPF and PBAND3, which select from the total spectrum the values that will become the coefficients a, b, c, d, and the signals that will become the components I1, Q1, I2, Q2. The generic block A/D necessarily includes a sampler of the signal coming from the AGC. The sampling frequency can be selected with very low value, around 100 Hz, since the null frequency line is in reality an almost constant signal with a band lower than 50 Hz. Once the correction factors are obtained and neglecting the effects of the thermal drift, their values can remain unchanged for a long time, since the physical characteristics of the mixers slowly modify during the life cycle of the receiver, mainly due to ageing phenomena. In any case if the characteristics of the demodulated signal deteriorate, it is convenient to recalculate the correction factors. Considering also the thermal drift, it is necessary to prepare the RSBIL network for an automatic and repetitive operation; to this purpose the selector SEL must be electronically controlled to switch between the two selection positions in a cyclic way and with a set period.

Making reference to fig. 9, it can be noticed in detail the circuit forming the reconstruction network RSCOR. The configuration of such a circuit is the simple transposition in hardware of the expressions that solve the equation system previously indicated, keeping in mind that it is a digital hardware. In particular, we see that the network includes: 8 multipliers, 4 adders, 4 dividers of the numerator coming out for the adders for the determinant DET = (ad – bc), as well as 6 inverters. For the calculation of the determinant DET, 2 multipliers and 1 inverter are also required. Finally, four memory registers are required for coefficients a, b, c, d.

Making reference to fig. 10 it is now described a radioreceiver more general than the simplified one for two sole carriers, shown in fig. 3. As an indication, it has been selected a number of eight modulated carriers, representing eight communication channels. The spectral representations of figures 11, 12, 13 and 14 will be helpful in the description of the receiver. Comparing the receivers of figures 3 and 10 the following differences can be noticed for the receiver of fig. 10 :

A) there are four DDCx/y blocks having the same structure of block DDC1/2 in

fig. 3, namely: DDC4/5, DDC3/6, DDC2/7, DDC1/8 relevant to pairs of channels CH4/CH5, CH3/CH6, CH2/CH7 and CH1/CH8 that result symmetric versus the frequency of local oscillator, indicated with f_0 in fig. 11;

B) the numeric oscillators assume the same numbering FIRx/y of the DDCx/y block they belong to, namely: NCO4/5, NCO3/6, NCO2/7, NCO1/8 relating to DDC4/5, DDC3/6, DDC2/7, DDC1/8;

C) the low-pass filters upstream the network RSCOR assume the same numbering of FIRx/y of the block DDCx/y they belong to, and namely: FIR4/5, FIR3/6, FIR2/7, FIR1/8 in respect with DDC4/5, DDC3/6, DDC2/7, DDC1/8;

D) the signals z4'(t), z5'(t), z6'(t), z7'(t) are now indicated with $z4'(t)_{x/y}$, $z5'(t)_{x/y}$, $z6'(t)_{x/y}$, $z7'(t)_{x/y}$ being specific of the block DDCx/y they belong to; and

E) the RSBIL network has now as many outputs as are the RSCOR networks, and therefore the DDCx/y blocks it is connected to.

Fig. 11 shows the frequency spectrum Z1'(f) of the entering multicarrier signal z1(t) filtered by the PBAND filter, where 8 contiguous spectrum S1(f),....,S8(f), can be noticed, occupying a total band BW, relevant to a same number of communication channels CH1,...,CH8, each of them occupying a band having BC width. Whenever the receiver of fig. 10 was employed in a GSM mobile system GSM, the eight channels CH1,...,CH8 would actually correspond to 54 channels received, time-shared on 8 carriers selected among the 174 possible ones (number 8 is only a design choice). Should the receiver belong to a Base Transceiver Station (BTS) of an EGSM system (extended GSM), the radiofrequency band pass filter PBAND would have 35 MHz bandwidth, with slope capable to attenuate the transmission band 10 MHz far; being the distance between the upper limit of the reception band (880 - 915 MHz) used for the communications between the Mobiles (MS) and the Base Transceiver Station (BTS) and the lower limit of the transmission band. (925 - 960 MHz). Remaining in the example, when the receiver is employed in the BTS the frequency f_0 of local oscillator shall be 897.5 MHz in order to subdivide the total band into two equal half bands. In any case the f_0 must be selected in order to symmetrically subdivide the N channels in the BW band. Fig. 11 shows the case with N pair, as it occurs in the EGSM where N = 174, from which it can be noticed that the f_0 falls between the two central channels

and subdivides the BW band into two groups of N/2 channels each, shifted, due to the demodulation, in the same lower half base band BW/2, as in fig. 12. On the contrary, in the case of odd N, the f_0 is placed however at the centre of the distance separating the spectrum of frequencies of two central channels, the channel placed at one or at the other band limit and that does not find its mate, joins the noise present in the position of the spectrum symmetrical to it, versus the frequency f_0.

Fig. 12 shows the spectrum of frequencies Z2'(f), or in equivalent manner Z3'(f), of the signal z2'(t), or z3'(t), coming out from the demodulator DEMI/Q. As for fig. 5, it can be noticed that, due to the particular choice of the frequency f_0 of local oscillator placed in the middle of the BW band, the radiofrequency signal is converted through direct demodulation within a base band having BW/2 width and the symmetric channels versus the frequency f_0 undergo a spectral superimposition. More in particular, the pairs of superimposed channels shall be: CH4/CH5, CH3/CH6, CH2/CH7, CH1/CH8.

Demodulators DEMx and DEMy, relevant to each DDCx/y block, can correctly operate using two isofrequential carriers in phase quadrature supplied by the relevant pair of NCOx/y. The above mentioned carriers have a frequency $fp_{x/y}$ equal to the band centre one of the pairs of superimposed channels in base band, that is: $fp_{x/y} = \frac{1}{2}PC, \frac{3}{2}PC, \ldots\ldots, \frac{7}{2}PC$, where PC indicates the channel spacing , irrespective of the fact that N is pair or odd.

At the output of demodulators DEMx and DEMy there will be some components at double frequencies $2fp_{x/y}$ that shall be removed by the four identical filters FIRx/y, therefore said filters shall have bandwidth within 0 and BC/2.

Inside the generic block DDCx/y the signals $z4'(t)_{x/y}$, $z5'(t)_{x/y}$, $z6'(t)_{x/y}$, $z7'(t)_{x/y}$ shall originate an equation system similar to that of the two-channel receiver of fig. 3, and that can be obtained from the same replacing the indexes 1, 2 by more generic ones x, y specified time by time.

The RSCOR networks are all identical, since they must correct the dissymmetries of the analogue demodulator DEMI/Q which is unique for all the DDCx/y block. The receiver of fig. 10 is suitable to a "dynamic" operation, that is with channels assigned in a dynamic way, just like it is required in the GSM,

being sufficient to this purpose to change the value of the frequency $fp_{x/y}$ of a given block DDCx/y to receive a corresponding pair of channels. The numeric implementation of the blocks FIRx/y, NCOx/y, DEMx and DEMy shall therefore support this dynamic characteristic, the methods according to which this is possible being known by those skilled in the art, in general the frequency change is sufficient.

Finally, the components in phase and in quadrature of the single channels must be sent to the demodulator GMSK to obtain again the bit flow of the transmission burst.

In the case a symmetric mate versus the f_0, does not correspond to a given channel since it is not comprised in the canalization assigned to the receiver, no modification shall be made to the receiver architecture, because the signal of the missing symmetric channel is replaced by the noise present in this position of the spectrum.

As for the hardware implementation of the digital portion of the receiver, it can be selected the use of one or more mathematical microprocessors (DSP), or decide for the design of a dedicated integrated circuit (ASIC); this last possibility resulted to be the more suitable.

Therefore, while some embodiments of the present invention have been shown and described, it should be understood that it is not limited thereto, but extends to cover all other embodiments that may be clear to those skilled in the art without departing from the scope thereof. It is thus contemplated that the present invention encompasses any and all such embodiments covered by the following claims.

CLAIMS

1. Process for the implementation of a broad band receiver for a signal (z1(t)) consisting of a plurality of equispaced carriers, orthogonally modulated by the information conveyed by relevant channels (CH1,...,CH8) associated to the same, including a radiofrequency filtering with band pass (PBAND) characteristic for the suppression of signals not included in the band of said multicarrier signal, **characterized in that** it includes in sequence the following steps:

- direct demodulation (DEMI/Q) of the filtered signal (z1'(t)) by multiplication of the same by the two first local carriers in phase quadrature ($\cos\omega_0 t$, $-\sin\omega_0 t$), having equal frequency, corresponding to a central value of the spectrum of the radiofrequency multicarrier signal, superimposing by this, in a lower half of the base band pairs of channels (CH4,CH5;...;CH1,CH8) symmetrically arranged versus the frequency of said first local carriers;
- first filtering in base band, broad band, of components in phase (z2'(t)) and in quadrature (z3'(t)) of the demodulated multicarrier signal, for the suppression of additional components outside the interest band;
- sampling of said components, filtered at a sampling frequency equal to the bandwidth (BW) of said multicarrier signal, and subsequent analogue/digital conversion (A/D);
- second demodulation (DEM4, DEM5;...;DEM1, DEM8) of said filtered components converted to digital, in phase and in quadrature, by multiplication of the same components by pairs of relevant second numeric local carriers in phase quadrature among them, having frequency equal to the value of centre band of said pairs of superimposed channels, obtaining, coinciding with said second isofrequential numeric carriers, quartets of double demodulated signals ($z4'(t)_{4/5}$, $z5'(t)_{4/5}$, $z6'(t)_{4/5}$, $z7'(t)_{4/5}$;......; $z4'(t)_{1/8}$, $z5'(t)_{1/8}$, $z6'(t)_{1/8}$, $z7'(t)_{1/8}$) that can be analytically expressed through a linear system of four equations in four unknown values, corresponding to in phase (I4, I5;...;I1, I8) and in quadrature (Q4, Q5;...;Q1, Q8) components of the channels of said pairs of superimposed channels;
- solution of said linear systems (RSOM) obtaining the above mentioned components (I4, Q4; I5, Q5;...; I1, Q1; I8 Q8) for each single channel of said

pairs of channels, thus eliminating the equivocation in base band.

2. Process according to claim 1, characterized in that said linear systems have the following generic expression:

$z4(t)_{x/y} = \frac{1}{4}(Ix + Iy)$

$z5(t)_{x/y} = \frac{1}{4}(Qy - Qx)$

$z6(t)_{x/y} = \frac{1}{4}(Qx + Qy)$

$z7(t)_{x/y} = \frac{1}{4}(Ix - Iy)$

where: $z4(t)_{x/y}$, $z5(t)_{x/y}$, $z6(t)_{x/y}$, $z7(t)_{x/y}$ are said double demodulated signals relevant to a generic pair of channels CHx, CHy, and Ix, Qx, Iy, Qy are the relevant said unknown components.

3. Process according to claim 1, in particular for signals with wide level dynamic among the different channels, characterized in that said first broad band filtering (PBAND3) of the demodulated signal is a band pass filtering that suppresses from the spectrum of the signal in base band the components around the null frequency; and that includes also the following additional steps completely independent from the previous sequence:

- measurement of the amplitude and phase dissymmetry degree on the two branches of an analogue demodulator (DEMI/Q) performing said direct demodulation from radiofrequency in base band, obtaining correction factors(a, b, c, d);
- introduction of said correction factors in said linear systems of equations, obtaining still linear modified systems having the same number of equations;
- solution of said modified systems (RSCOR), obtaining for each single channel of said pairs (CH4,CH5;...;CH1,CH8) the above mentioned components in phase and in quadrature, without unbalancing, otherwise due to said dissymmetries on the two branches of said analogue demodulator.

4. Process according to claim 3, characterized in that said additional phase for the measurement of the dissymmetry degree includes the following sub-phases:

- switching to the input of the receiver of a said first local carrier in phase ($\cos\omega_0 t$);
- narrow band low-pass filter (LPF) of the signals, in phase ($z2'(t)$) and in quadrature ($z3'(t)$), supplied by said analogue demodulator and conversion to

digital of the filtered signals, obtaining two first of said correction factors (a, c);

- switching to the input of the receiver of a said second local carrier in quadrature ($-\sin\omega_0 t$) in place of said first one;
- narrow band low-pass filter (LPF) of the signals, in phase ($z2'(t)$) and in quadrature ($z3'(t)$), supplied by said analogue demodulator and conversion to digital (A/D) of the filtered signals, obtaining two second of said correction factors (b, d).

5. Process according to claim 4, characterized in that said first local carrier in phase ($\cos\omega_0 t$), or in quadrature ($-\sin\omega_0 t$), is summed up (SOM) to the signal received ($z1'(t)$).

6. Process according to claims 4 or 5, characterized in that said first local carrier in phase ($\cos\omega_0 t$) and said first local carrier in quadrature ($-\sin\omega_0 t$) are cyclically selected.

7. Process according to claim 3, characterized in that said modified systems have the following generic expression:

$z4'(t)_{x/y} = a/2(Ix + Iy) + b/2(Qx + Qy)$

$z5'(t)_{x/y} = a/2(Qy - Qx) + b/2(Ix - Iy)$

$z6'(t)_{x/y} = d/2(Qx + Qy) + c/2(Ix + Iy)$

$z7'(t)_{x/y} = d/2(Ix - Iy) + c/2(Qy - Qx)$

where: $z4(t)_{x/y}$, $z5(t)_{x/y}$, $z6(t)_x$ doubly demodulated $_{/y}$, $z7(t)_{x/y}$ are said double demodulated signals relevant to a generic pair of channels CHx, CHy; Ix, Qx, Iy, Qy are the relevant said unknown components; a, b, c, d are said correction factors.

8. Process according to any of the previous claims when the number of channels is odd, characterized in that said first two local carriers in phase quadrature ($\cos\omega_0 t$, $-\sin\omega_0 t$), are placed at the centre of the distance separating the spectrum of frequencies of the two central channels, the channel placed at one or at the other band limit that does not find its mate, joins the noise present in the position of the spectrum symmetric to the same in respect with said first carriers.

9. Process according to any of the previous claims, when a given channel does not correspond to a symmetric mate in respect with said two first

local carriers in phase quadrature ($\cos\omega_0 t$, $-\sin\omega_0 t$), characterized in that the signal of the missing symmetric channel is replaced by the noise in this position of the spectrum.

10. Broad band receiver for a signal ($z1(t)$) consisting of a plurality of equispaced carriers, orthogonally modulated by the information conveyed by relevant channels (CH1,...,CH8) associated to the same, including a radiofrequency filter with characteristic band pass (PBAND) for the suppression of signals not included in the band of said multicarrier signal, **characterized in that** it includes:

- first direct demodulation means of the filtered signal ($z1'(t)$), multiplying said signal by two first local carriers in phase quadrature ($\cos\omega_0 t$, $-\sin\omega_0 t$), of equal frequency, corresponding to a central value of the spectrum of the radiofrequency multicarrier signal, superimposing by this within the lower half of the base band (BW) pairs of channels (CH4,CH5;...;CH1,CH8) symmetrically arranged versus the frequency (f_0) of said first local carriers;
- first filtering means in base band, broad band, of components in phase ($z2'(t)$) and in quadrature ($z3'(t)$) of the demodulated multicarrier signal, for the suppression of additional components outside the interest band;
- sampling means of said filtered components ($z2'(t)$, $z3'(t)$) and of subsequent analogue/digital conversion, operated by a sampling frequency equal to the bandwidth (BW) of said multicarrier signal;
- second demodulation means (DEM4, DEM5;...;DEM1, DEM8) placed downstream said analogue/digital conversion means, controlled by pairs of relevant second numeric local carriers in phase quadrature among them, having frequency equal to the value of band centre of said pairs of superimposed channels, said second demodulation means obtaining, coinciding with said second isofrequential numeric carriers, quartets of double demodulated signals ($z4'(t)_{4/5}$, $z5'(t)_{4/5}$, $z6'(t)_{4/5}$, $z7'(t)_{4/5}$;......; $z4'(t)_{1/8}$, $z5'(t)_{1/8}$, $z6'(t)_{1/8}$, $z7'(t)_{1/8}$) that can be analytically expressed through a linear system of four equations in four unknown values, corresponding to components in phase (I4, I5;...;I1, I8) and in quadrature (Q4, Q5;...;Q1, Q8) of the channels of said pairs;
- solution means of said linear systems (RSOM), obtaining the above

mentioned components (I4, Q4; I5, Q5;...; I1, Q1; I8 Q8) for each single channel of said pairs of channel, thus eliminating the equivocation in base band.

11. Receiver according to claim 10, in particular for signals with wide level dynamic among the different channels, characterized in that said first filtering means in base band are band pass filters that suppress from the spectrum of the signal in base band the components around the null frequency.

12. Receiver according to claim 11, characterized in that it also includes:

- measurement means of the amplitude and phase dissymmetry degree on two branches of an analogue demodulator (DEMI/Q) belonging to said first demodulation means, and to obtain correction factors (a, b, c, d);
- alternative means (RSCOR) for the solution of said linear systems, that receive said correction factors (a, b, c, d) and operate on the basis of the same and of the quartets of double demodulated signals, said double demodulated signals being analytically expressed through linear combinations of the correction factors and of said corresponding components in phase (I4, I5;...;I1, I8) and in quadrature (Q4, Q5;...;Q1, Q8) of the channels of said pairs (CH4,CH5;...;CH1,CH8); said alternative means (RSCOR) obtaining said components in phase and in quadrature, free from unbalancing otherwise due to said dissymmetries on the two branches of said analogue demodulator (DEMI/Q).

13. Receiver according to claim 12, characterized in that said measurement means of the dissymmetry degree include:

- a selector (SEL) switching to the input of the receiver either one or the other of the two test signals consisting of said first local carrier in phase ($\cos\omega_0 t$), or in quadrature ($-\sin\omega_0 t$);
- a narrow band low-pass filter (LPF), with an analogue/digital converter in cascade, that supplies two first factors of said correction factors (a, c) relevant to a first branch of said analogue demodulator (DEMI/Q), or two second of said correction factors (b, d) relevant to a second branch of said analogue demodulator (DEMI/Q).

14. Receiver according to claim 13, characterized in that said means for

the measurement of the dissymmetry degree include also a two-input adder (SOM) adding to the multicarrier signal received and filtered at radiofrequency (z1'(t)) a said selected test signal ($\cos\omega_0 t$, $-\sin\omega_0 t$) and giving the total signal to the input of the receiver.

15. Receiver according to claims 13 or 14, characterized in that said selector (SEL) is of the electronic type and is alternatively and cyclically controlled.

16. Receiver according to any claim 10 to 15, when the number of channels is odd, characterized in that said two first local carriers in phase quadrature ($\cos\omega_0 t$, $-\sin\omega_0 t$), are placed at the centre of the distance separating the frequency spectrum of two central channels, the channel placed at one or at the other band limit that does not find its mate, joins the noise present in the position of the spectrum symmetric to the same in respect with said first carriers.

17. Receiver according to any claim 10 to 16, when a symmetric mate does not match, in respect with said two first local carriers in phase quadrature ($\cos\omega_0 t$, $-\sin\omega_0 t$), characterized in that the signal of the missing symmetric channel is replaced by the noise present in this position of the spectrum.

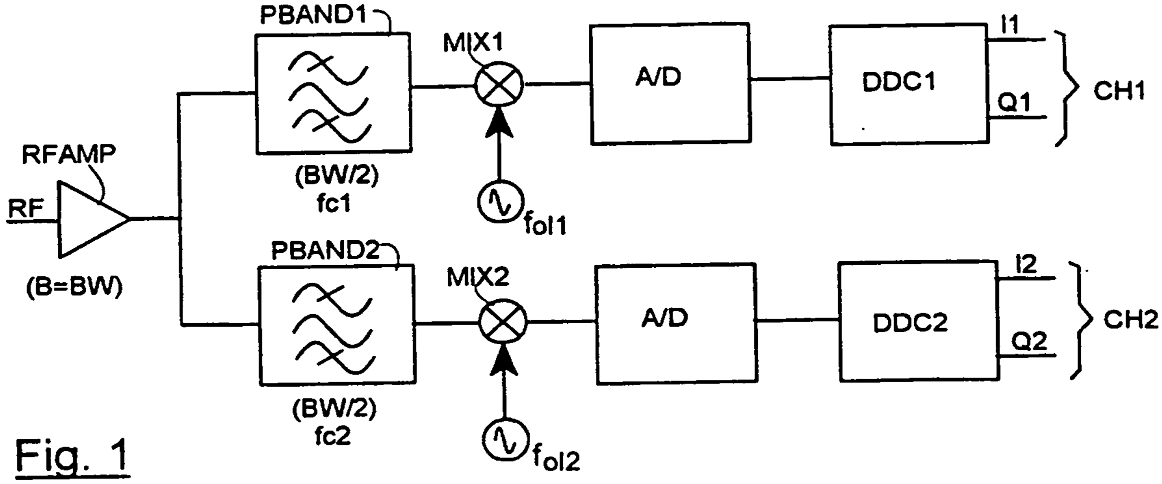


Fig. 1

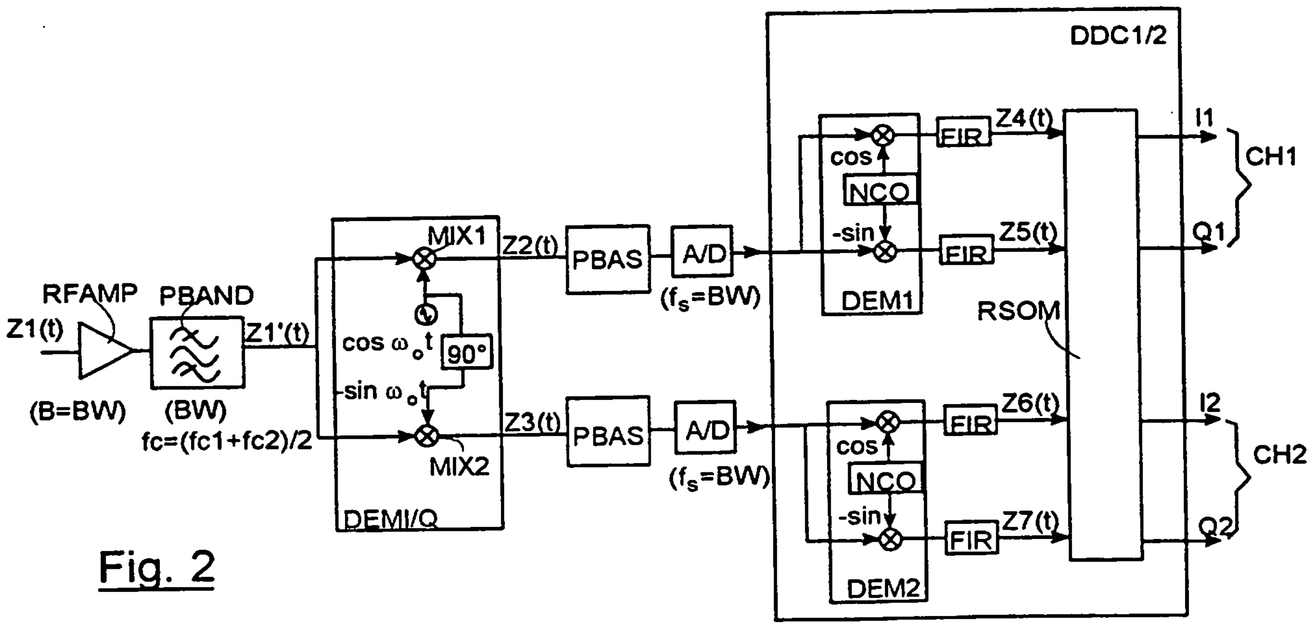


Fig. 2

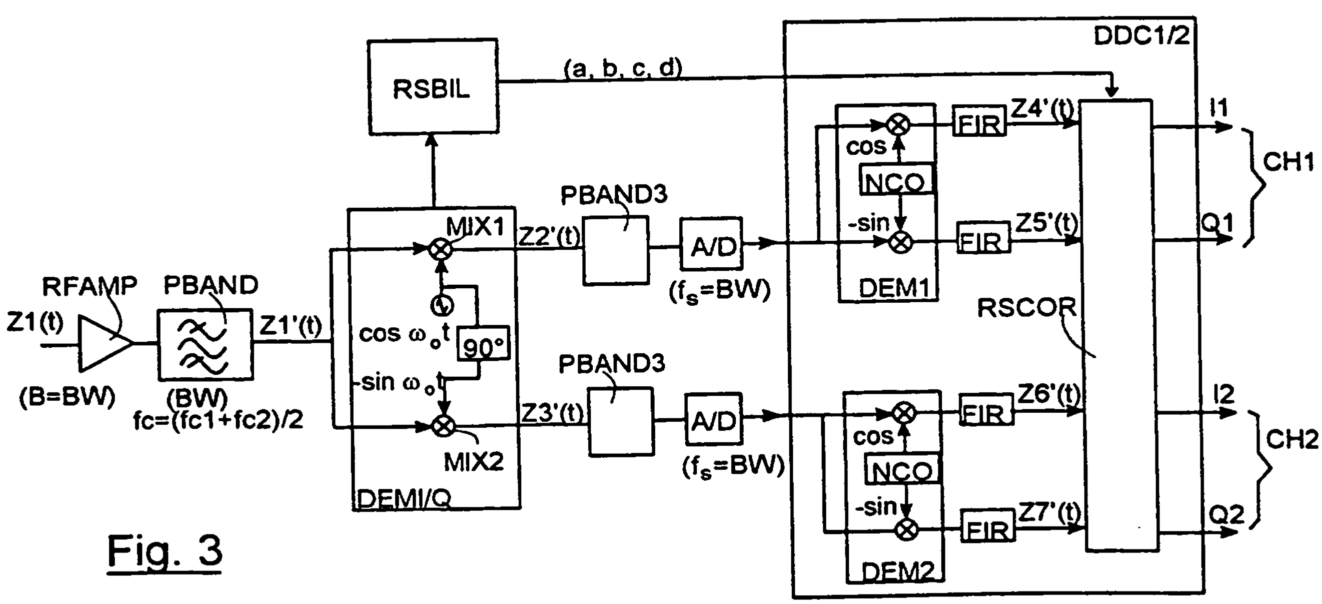


Fig. 3

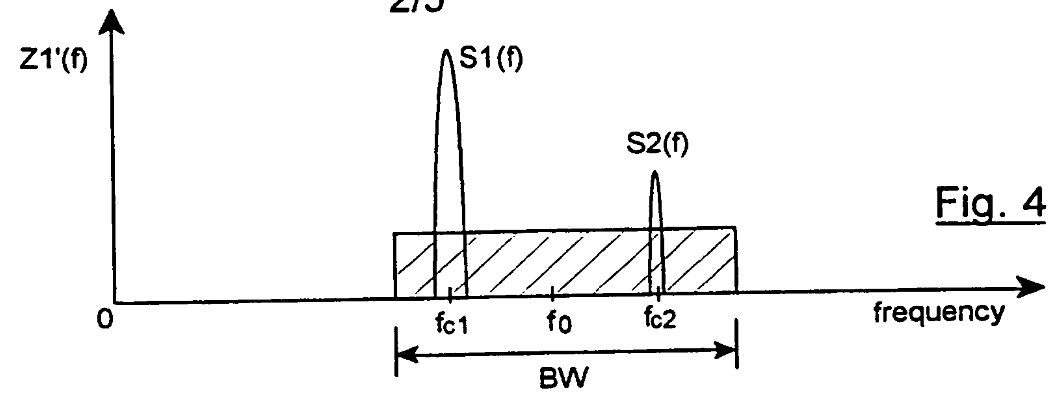


Fig. 4

Fig. 5

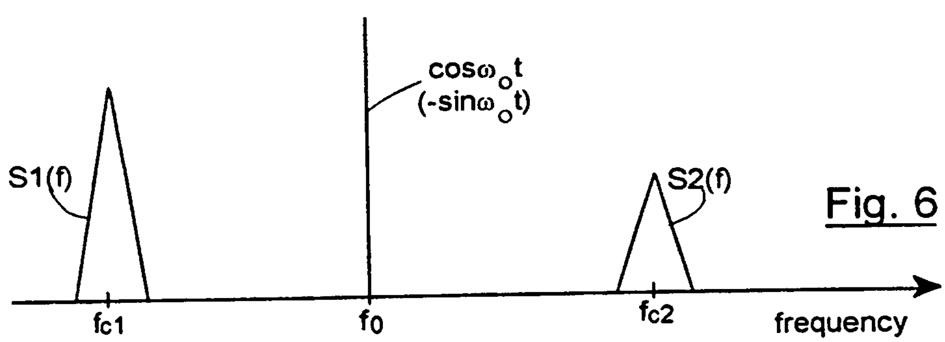


Fig. 6

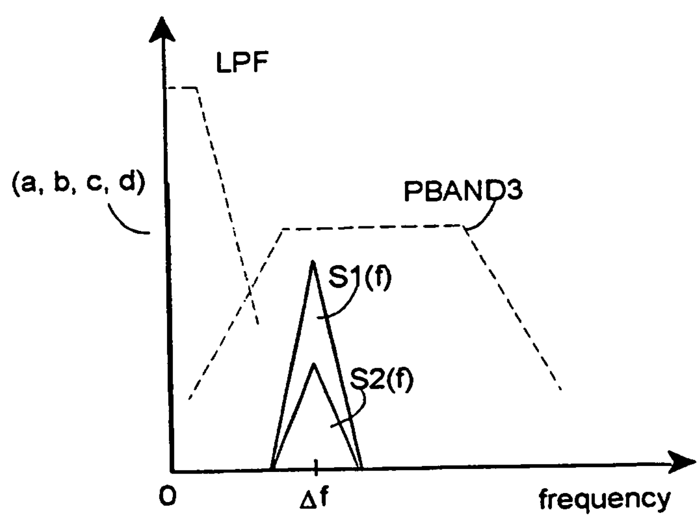
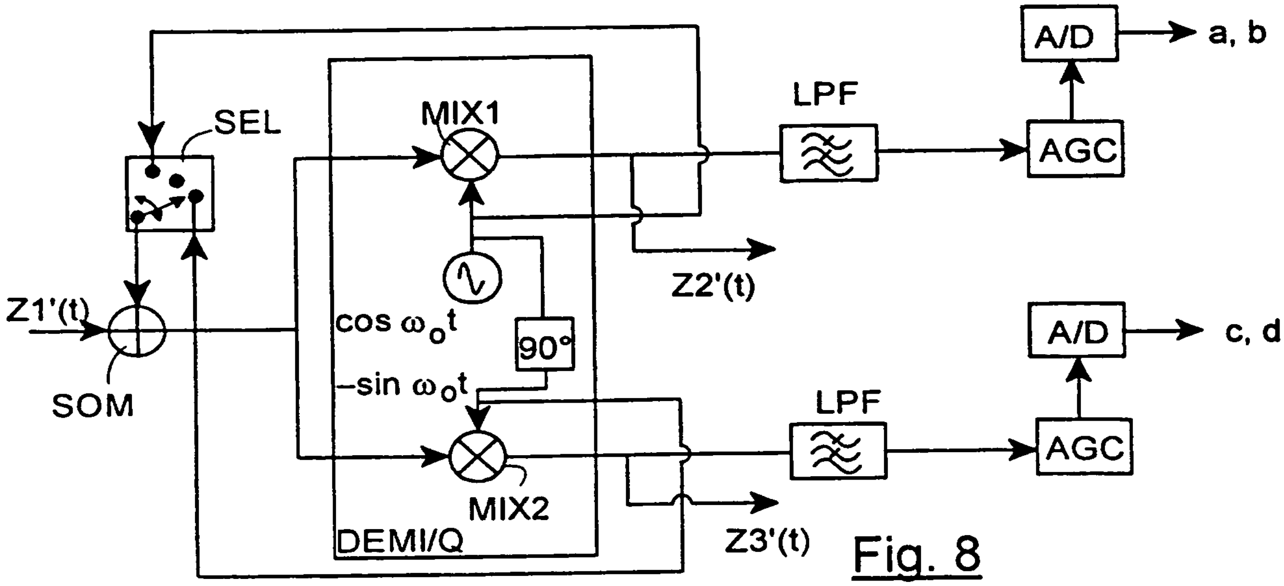
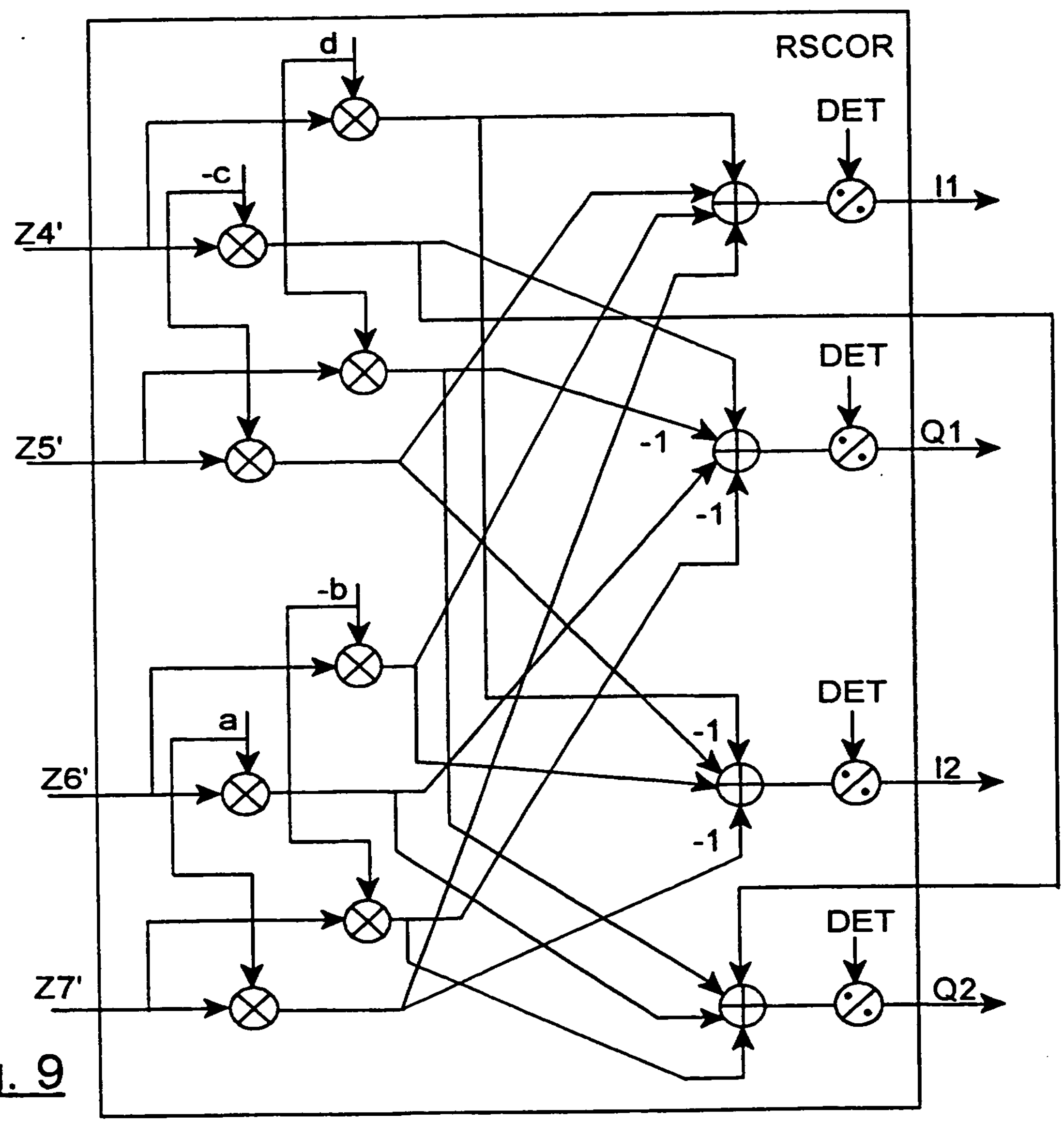


Fig. 7



SEL
MIX1
LPF
A/D
a, b
AGC
Z2'(t)
Z1'(t)
SOM
cos ωot
90°
-sin ωot
A/D
c, d
LPF
AGC
MIX2
DEMI/Q
Z3'(t)

Fig. 8



RSCOR
d
DET
-c
I1
Z4'
DET
Z5'
-1
Q1
-1
-b
DET
a
-1
I2
Z6'
-1
DET
Z7'
Q2

Fig. 9

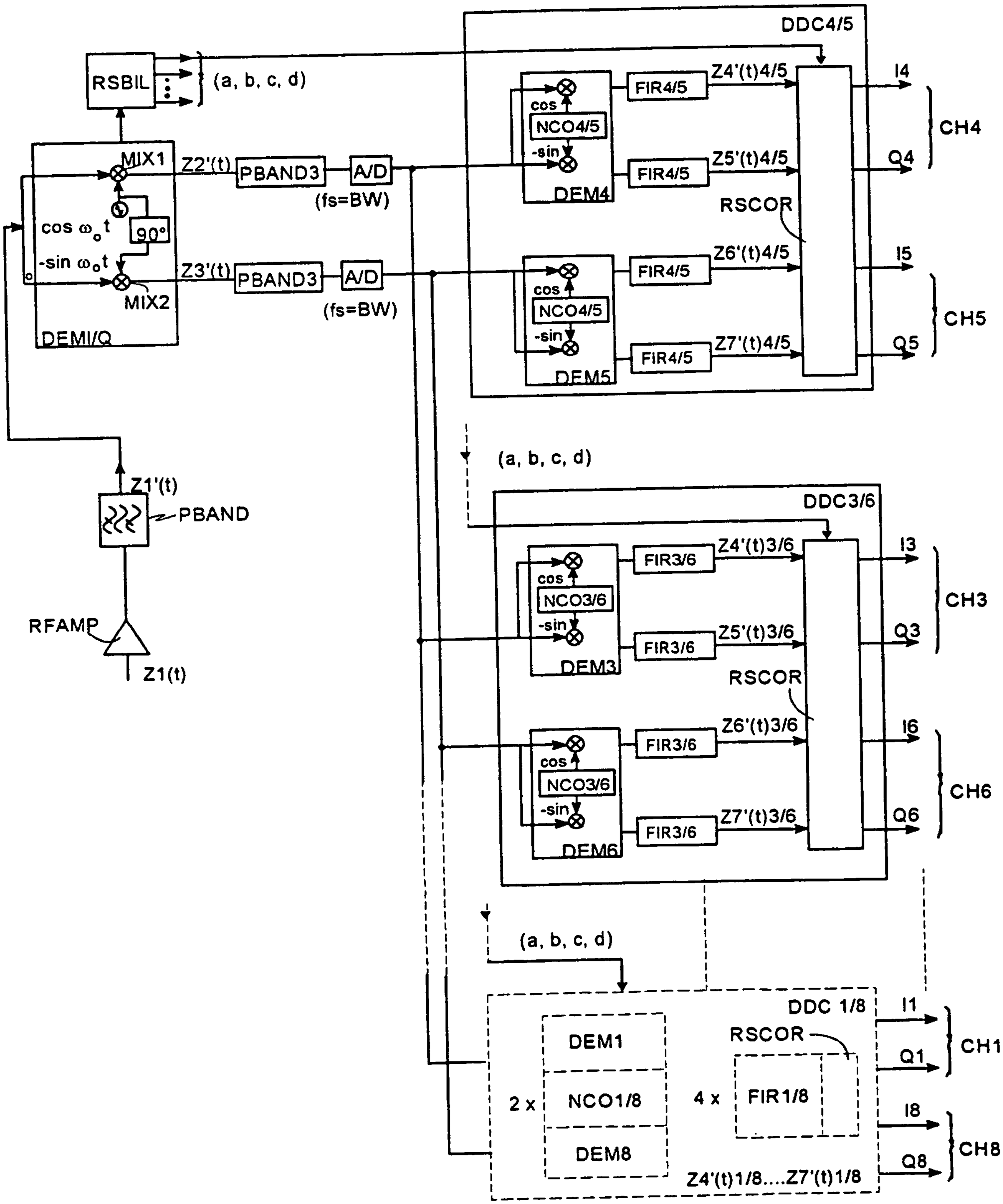

DDC4/5
RSBIL
(a, b, c, d)
MIX1
Z2'(t)
PBAND3
A/D
(fs=BW)
cos ωₒt
90°
-sin ωₒt
MIX2
Z3'(t)
DEMI/Q
cos
NCO4/5
-sin
DEM4
FIR4/5
Z4'(t)4/5
Z5'(t)4/5
RSCOR
I4
Q4
CH4
DEM5
Z6'(t)4/5
Z7'(t)4/5
I5
Q5
CH5
Z1'(t)
PBAND
RFAMP
Z1(t)
DDC3/6
NCO3/6
DEM3
FIR3/6
Z4'(t)3/6
Z5'(t)3/6
I3
Q3
CH3
DEM6
Z6'(t)3/6
Z7'(t)3/6
I6
Q6
CH6
DDC 1/8
DEM1
2 x
NCO1/8
DEM8
4 x
FIR1/8
Z4'(t)1/8....Z7'(t)1/8
I1
Q1
CH1
I8
Q8
CH8

Fig. 10

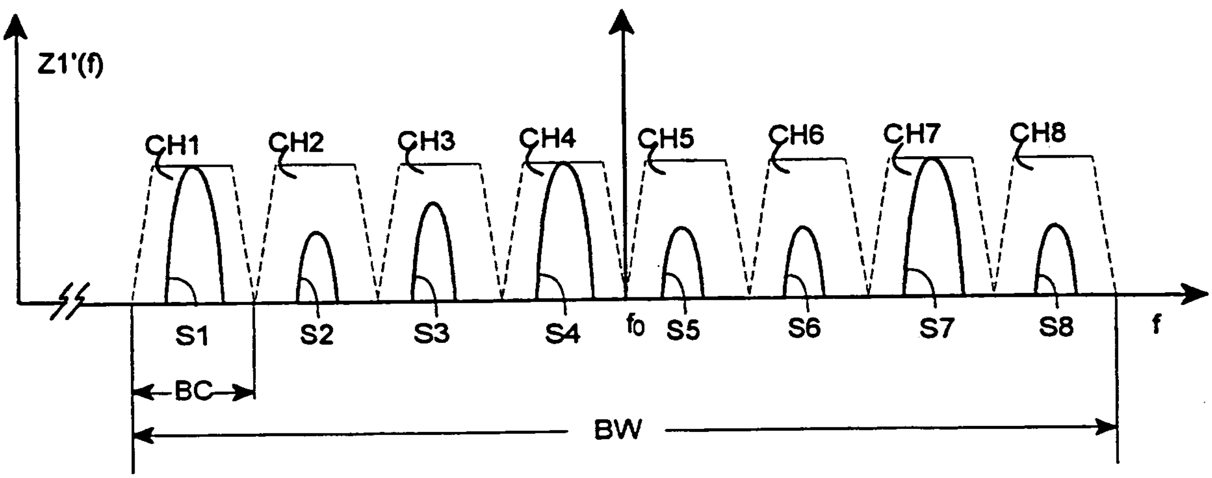

Z1'(f)
CH1
CH2
CH3
CH4
CH5
CH6
CH7
CH8
S1
S2
S3
S4
f0
S5
S6
S7
S8
f
BC
BW

Fig. 11

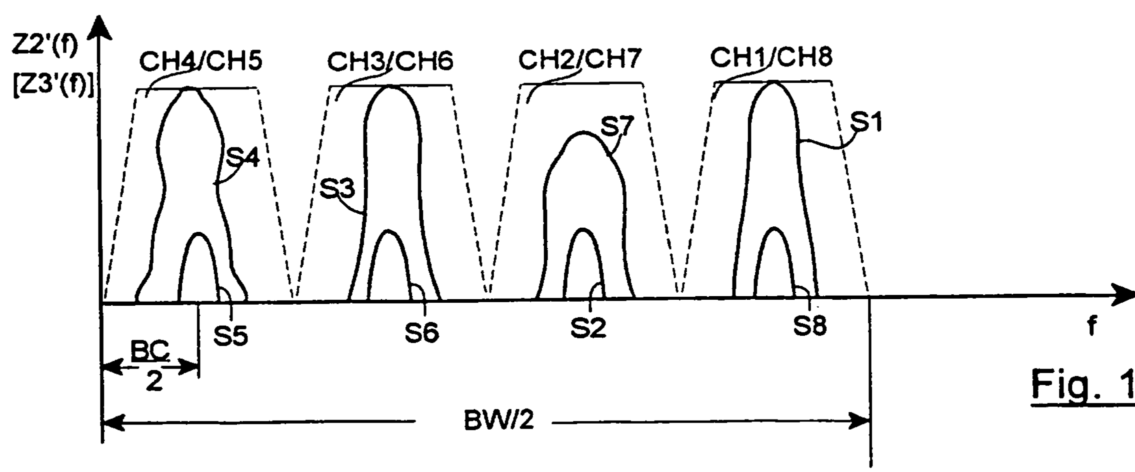

Z2'(f)
[Z3'(f)]
CH4/CH5
CH3/CH6
CH2/CH7
CH1/CH8
S4
S3
S7
S1
S5
S6
S2
S8
f
BC
2
BW/2

Fig. 12

INTERNATIONAL SEARCH REPORT

Interr   nal Application No
PCT/EP 98/05749

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6   H04B1/30   H03D7/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6   H04B   H04Q   H03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 656 701 A (NIPPON TELEGRAPH & TELEPHONE) 7 June 1995 see abstract see column 3, line 24 - column 4, line 2 see column 7, line 44 - column 9, line 20 see figure 3 see figure 4A see figure 6 ---	1,3, 10-12
A	WO 94 02996 A (ROKE MANOR RESEARCH ;HULBERT ANTHONY PETER (GB)) 3 February 1994 see abstract see page 12, line 14 - page 14, line 25 see figure 2 see figure 3 --- -/--	1,10

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 February 1999	18/02/1999

Name and mailing address of the ISA	Authorized officer
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1

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 95 12261 A (AIRNET COMMUNICATIONS CORP) 4 May 1995 see abstract see page 17, line 25 - page 21, line 20 see figure 2 see figure 3 -----	1,10

1

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/EP 98/05749

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0656701 A	07-06-1995	CA 2136592 A	27-05-1995
		CN 1113056 A	06-12-1995
		JP 7202784 A	04-08-1995
		US 5715235 A	03-02-1998
WO 9402996 A	03-02-1994	GB 2269075 A	26-01-1994
		EP 0605711 A	13-07-1994
		FI 941349 A	23-03-1994
		NO 941069 A	23-03-1994
		US 5483550 A	09-01-1996
WO 9512261 A	04-05-1995	US 5535240 A	09-07-1996
		AU 7981894 A	22-05-1995
		CA 2175242 A	04-05-1995
		DE 726000 T	12-12-1996
		EP 0726000 A	14-08-1996
		FI 961777 A	26-06-1996
		JP 9507618 T	29-07-1997
		US 5606575 A	25-02-1997
		US 5848097 A	08-12-1998